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(54) **PROVISIONING OF APPLICATION CATEGORIES AT A USER EQUIPMENT DURING NETWORK CONGESTION**

(57) Technology for provisioning categories of applications on a user equipment (UE) is disclosed. A registration update message may be received at a wireless network element from the UE over non-access stratum (NAS) signaling. Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information may be communicated from the wireless network element to the UE in

response to receiving the registration update message. The ACDC/ASAC may be activated at a selected prioritization level, at the wireless network element, while a wireless network channel condition of a wireless network exceeds a capacity threshold, the ACDC/ASAC enabling only application categories to operate at the UE that are contained in the ACDC/ASAC information.

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Description

RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Patent Application No. 61/806,821, filed March 29, 2013 with a docket number of P55273Z, the entire specification of which is hereby incorporated by reference in its entirety for all purposes.

BACKGROUND

[0002] Wireless mobile communication technology uses various standards and protocols to transmit data between a node (e.g., a transmission station) and a wireless device (e.g., a mobile device). Some wireless devices communicate using orthogonal frequency-division multiple access (OFDMA) in a downlink (DL) transmission and single carrier frequency division multiple access (SC-FDMA) in an uplink (UL) transmission. Standards and protocols that use orthogonal frequency-division multiplexing (OFDM) for signal transmission include the third generation partnership project (3GPP) long term evolution (LTE), the Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard (e.g., 802.16e, 802.16m), which is commonly known to industry groups as WiMAX (Worldwide interoperability for Microwave Access), and the IEEE 802.11 standard, which is commonly known to industry groups as WiFi.

[0003] In 3GPP radio access network (RAN) LTE systems, the node can be a combination of Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node Bs (also commonly denoted as evolved Node Bs, enhanced Node Bs, eNodeBs, or eNBs) and Radio Network Controllers (RNCs), which communicates with the wireless device, known as a user equipment (UE). The downlink (DL) transmission can be a communication from the node (e.g., eNodeB) to the wireless device (e.g., UE), and the uplink (UL) transmission can be a communication from the wireless device to the node.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Features and advantages of the disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the disclosure; and, wherein:

FIGS. 1A and 1B are tables illustrating a prioritization of Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) applications or application categories in accordance with an example;
FIG. 2 illustrates an implementation of a prioritization scheme for applications or application categories between a network and a user equipment (UE) in accordance with an example;

FIG. 3 illustrates a plurality of geographical region borders that are defined based on a combination of location area codes (LACs), routing area codes (RACs) and type allocation codes (TACs) in accordance with an example;

FIG. 4 illustrates a network element communicating a state indicator message to a user equipment (UE) in response to receiving a non-access stratum (NAS) message from the UE in accordance with an example;

FIG. 5 illustrates Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information included in an elementary file (EF) communicated to a mobile device in accordance with an example;

FIG. 6 illustrates a network element communicating Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information in response to receiving a non-access stratum (NAS) message from the UE in accordance with an example;

FIG. 7 illustrates a network element determining that no application categories on a preconfigured list of application categories are allowed to operate at a user equipment (UE) when Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) is activated and the UE is roaming outside a home geographical region in accordance with an example;

FIG. 8 illustrates a network element determining that no application categories on a preconfigured list of application categories are allowed to operate at a user equipment (UE) when the UE is roaming outside a home geographical region and regardless of whether Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) is activated in accordance with an example;

FIG. 9 illustrates a network element communicating Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information to a user equipment (UE) indicating whether application categories on a preconfigured list of application categories are allowed to operate at the UE when the UE is roaming outside a home geographical region and ACDC/ASAC is activated in accordance with an example;

FIG. 10 depicts functionality of computer circuitry of a wireless network element operable to provision categories of applications on a mobile device in accordance with an example;

FIG. 11 depicts functionality of computer circuitry of a user equipment (UE) operable to operate applications according to a preconfigured white list of prioritized application categories in accordance with an example;

FIG. 12 depicts a flowchart of a method for provisioning categories of applications on a user equipment (UE) in accordance with an example; and FIG. 13 illustrates a diagram of a wireless device (e.g., UE) in accordance with an example.

[0005] Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended.

DETAILED DESCRIPTION

[0006] Before the present invention is disclosed and described, it is to be understood that this invention is not limited to the particular structures, process steps, signaling protocol and exchanges, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular examples only and is not intended to be limiting. The same reference numerals in different drawings represent the same element. Numbers provided in flow charts and processes are provided for clarity in illustrating steps and operations and do not necessarily indicate a particular order or sequence.

EXAMPLE EMBODIMENTS

[0007] An initial overview of technology embodiments is provided below and then specific technology embodiments are described in further detail later. This initial summary is intended to aid readers in understanding the technology more quickly but is not intended to identify key features or essential features of the technology nor is it intended to limit the scope of the claimed subject matter.

[0008] The number of applications that are being downloaded, installed and operated on user equipments (UEs), such as mobile devices, tablet computers, laptop computers, etc., is continually growing at an increasing rate. These applications may include social networking applications, online shopping applications, news applications, educational applications, music applications, video streaming applications, and so on. Several standard developing organizations (SDOs), including 3GPP, have identified that the growing number of applications operating at the UEs are a major cause of network inefficiencies. These applications may (intentionally or unintentionally) cause congestion over a Radio Access Network (RAN) and Core Network (CN) owing to access for services.

[0009] During network congestion, particularly during emergency situations, it may be desirable to restrict certain applications or categories of applications (e.g., social networking applications, video streaming applications) to access the wireless network in order to protect and/or

free up valuable wireless network resources. In other words, certain applications may be restricted when a wireless network or channel condition of the wireless network exceeds a capacity threshold. In addition, certain applications or categories of applications (e.g., emergency response applications) may be given priority when the wireless network is congested when these emergency situations occur. The certain applications or categories of applications may be restricted as long as the restriction complies with regional/national or countrywide net neutrality regulations. As an example, after a severe earthquake in a geographical region, packet-based communication applications that confirm the safety of citizens (e.g. Disaster Message Board service, Disaster Voice Messaging service) when a natural disaster or particularly newsworthy event occurs may be given priority over video streaming applications during the emergency situation.

[0010] There are also applications that cause other problems, e.g. applications that disclose privacy information without user consent, or applications that encourage illegal activities that are prohibited by the local regulations. It may be desirable to restrict these problematic applications from accessing the wireless network, as long as the restriction is in compliance with regional/national or countrywide net neutrality regulations.

[0011] In 3GPP, the study of Application Specific Congestion Control for Data Communications (ACDC) have yielded a subset of work called Application and Service Access control (ASAC). ACDC/ASAC is further described in 3GPP Technical Report (TR) 22.806 V1.0.0. Both ACDC and ASAC have approved "white list/lists" of allowed applications or application categories to be pre-configured or downloaded onto the UE. As used herein, the term "white list" generally refers to a list of applications or categories of applications that are allowed to operate at the user equipment (UE) when ACDC/ASAC is activated by the wireless network. The terms "application categories" or "categories of applications" may be used interchangeably and can indicate one or more applications that are grouped together. For example, social networking applications may be grouped into a first application category and the most popular applications among users of ages 18-35 may be grouped into a second application category. The "white list" may be dynamically configured or provisioned by the wireless network on an as-needed basis. Therefore, network congestion may be alleviated by temporarily preventing applications or categories of applications that are not listed on the "white list" to be initiated by the UE when ACDC or ASAC is activated by the network operators. ACDC/ASAC may be activated to relieve network congestion subject to regional/national or countrywide regulations.

[0012] The preconfigured white list of applications or application categories that are allowed to access the wireless network may contribute towards alleviation of the network congestion, but may not necessarily alleviate network congestion caused by competing approved ap-

plications on the preconfigured white list. In other words, the various approved applications on the preconfigured white list may still cause network congestion. However, as discussed in further detail below, network congestion caused by competing approved applications on the preconfigured white list may be alleviated.

[0013] The ACDC/ASAC functionality may be implemented across two end points - the UE and a network element. In one example, the network element may include an ACDC/ASAC server. The ACDC/ASAC server is a network entity that provisions the ACDC/ASAC white lists on the UE, as well as activates, deactivates, and manages the overall ASAC functionality from a mobile network operator (MNO) perspective. In one configuration, the ACDC/ASAC server may be a standalone network entity, and in this configuration, the ACDC/ASAC server may use Simple Object Access Protocol (SOAP)/Extensible Markup Language (XML) based transport to communicate with the UE. Alternatively, the ACDC/ASAC server may be collocated with other network entities. For example, the ACDC/ASAC server may be collocated with a mobility management entity (MME) and use non-access-stratum (NAS) transport to communicate with UE. In addition, the ACDC/ASAC server may be collocated with an Access Network Discovery and Selection Function (ANDSF) and use Open Mobile Alliance Device Management (OMA-DM) transport to communicate with UE.

[0014] Applications or categories of applications may be prioritized according to an approved list of applications or application categories when ACDC/ASAC is activated. In other words, categories of applications (e.g., emergency service applications) may be prioritized during network congestion or emergency situations. The network congestion may occur when a wireless network channel condition of the wireless network exceeds a capacity threshold. In addition, categories of applications may be prioritized during non-ACDC situations where an operator is not bounded by network neutrality (i.e., a principle that Internet service providers should treat all data on the Internet equally and not discriminate against specific types of content or applications) and is legally allowed to apply different treatment to applications on its UEs and network in normal non-emergency situations.

[0015] The prioritization scheme may be achieved by assigning some kind of value to each application or application category on a preconfigured list of applications or application categories. The values may be numerical, alphabetical, textual or a combination thereof.

[0016] FIG. 1A illustrates an exemplary prioritization scheme of ACDC applications. In Option 1, Applications A and B are given a first priority level (i.e., N), applications C and D are given a second priority level (i.e., N+1), applications E and F are given a third priority level (i.e., N+2), and applications G and H are given a fourth priority level (i.e., N+3). Alternatively, the prioritization scheme may apply to ACDC application categories. For example, Application Categories A and B may be given a first pri-

ority level, wherein Application Category A includes applications Q and R and Application Category B includes application S and T. In Option 2, the applications and/or application categories may be prioritized with finer granularity (e.g., N, N+1, N+3 and so on).

[0017] When an ACDC/ASAC condition is activated, the UE may allow the initiations of the applications or application categories on the approved list. In the event when more than one application or application category is initiated on the UE, the UE may prioritize the initiations according to the prioritization value assigned to the applications or application categories. Therefore, an assumption may be made that all applications or application categories on the white list are allowed to be initiated by the UE. The UE may then prioritize among the different applications or application categories according to a priority level assigned to each application or application category if there is competing demands on the UE to execute these applications or application categories in multitasking scenarios.

[0018] In an alternative configuration, a network operator may activate different levels of ACDC/ASAC based on the network congestion conditions, thereby allowing only the prioritized applications allowed for that condition level and disallowing the rest of the applications on the white list. Thus, the network operator may allow only the prioritized application categories allowed for that condition level and disallow the rest of the application categories on the white list. The different levels of ACDC/ASAC may be useful in situations where the operator needs to ensure that certain applications on the white list are given priority access to the wireless network over the other applications on the list. For example, at the onset of a major earthquake, the operator may want to ensure that a Disaster Message Board is allowed to access the wireless network while video upload to YouTube (e.g., a specific application) be granted access 24 hours later when a different ACDC/ASAC condition level is activated. Alternatively, the operator may restrict all video streaming applications (e.g., a specific application category) for 24 hours at the onset of the major earthquake, while only allowing for emergency service applications to communicate with the wireless network.

[0019] FIG. 1B is an exemplary prioritization scheme illustrating how an operator may prioritize the various allowed applications on its ACDC or ASAC white list and the corresponding ACDC/ASAC condition levels when the applications are allowed to be initiated by the UEs. Alternatively, the prioritizations scheme in FIG. 1B may apply to specific application categories that are allowed based on the ACDC/ASAC condition levels. The values may be numerical, alphabetical, textual or a combination thereof. For example, "A" may indicate an emergency response application or an emergency response application category. As shown in FIG. 1B, "A" and "B" may be allowed to access the wireless network at condition level N, but "C" through "H" may not be allowed until a future time. For example, "E" and "F" may only access

the wireless network when the wireless network allows condition N+2 and N+3.

[0020] As shown in FIG. 1B, when "C" through "H" are allowed to access the wireless network, "A" and "B" may also be allowed to access the wireless network. In other words, "A" and "B" may be allowed during condition levels N, N+1, N+2 and N+3. Therefore, "A" and "B" may be given a first priority level, "C" and "D" may be given a second priority level, "E" and "F" may be given a third priority level, and "G" and "H" may be given a fourth priority level. As shown in FIG. 1B, during a condition level of "N+1," "A" through "D" may be allowed to access the wireless network, but "E" through "H" are not allowed to access the wireless network, and so on.

[0021] FIG. 2 illustrates an exemplary implementation of a prioritization scheme for applications or application categories between a network and a user equipment (UE). The network may activate the ACDC/ASAC conditions, via an evolved node B (eNB), and the UE may initiate or operate applications or categories of applications according to the ACDC/ASAC conditions. The network may include a network element, such as the MME, ANDSF or a dedicated ACDC/ASAC server. Thus, the action of the ACDC/ASAC conditions may be initiated from the MME via the NAS protocol, the ANDSF through the OMA-DM protocol, or the dedicated ACDC/ASAC server via a hypertext transfer protocol (HTTP) protocol.

[0022] As shown in FIG. 2, the network may activate ACDC/ASAC condition level N. As a result, the UE may only initiate or operate applications A and B (or application categories A and B). Other applications or application categories on a white list are not allowed to be activated during condition level N. If the operator determines that a network congestion level is sufficiently alleviated to accommodate additional network traffic, the network may activate ACDC/ASAC condition level N+1. As a result, the UE may only initiate or operate applications A, B, C and D (or application categories A, B, C and D). In addition, the network may determine to activate ACDC/ASAC condition level N+3. As a result, the UE may initiate or operate applications A, B, C, D, E, F, G and H (or application categories A, B, C, D, E, F, G and H). In other words, all of the applications or application categories on the white list may be allowed to be activated by the UE.

[0023] An operator may be subject to different regulatory requirements within its service territory. For example, State X in Country A may have different regulatory requirements and priorities than State Y. In this case, the operator may configure the subscriber's UE and provision its wireless network to account for the differences between geographical regions. In one configuration, the UE may be preconfigured with the different white lists of the different regions. As the UE roams through different regions, the wireless network may dynamically activate the appropriate white list and deactivate the previous white list. For example, the UE may be preconfigured with white lists for geographical regions A, B and C. When the UE is in region A, only a white list corresponding to

region A may be activated, but when the UE roams to region B, a white list corresponding to region B may be activated and the white list corresponding to region A may be deactivated.

[0024] In an alternative configuration, the UE may be preconfigured with only the appropriate white list of the home region when the subscriber signs up for service. As the UE roams to a different region, the wireless network may dynamically replace the existing white list with the newly governing white list. As an example, when in region A, the UE may receive a white list corresponding to region A. When the UE roams to region B, the UE may receive a white list corresponding to region B and the white list corresponding to region A may no longer be applicable to the UE.

[0025] When the UE roams outside of a home geographical region, the network operator in the geographical region that the UE is roaming in may determine whether or not to honor a white list that is currently being implemented at the UE. For example, the UE may be implementing a white list corresponding to region A and the UE may roam into region B. The wireless network operator in region B may determine whether the UE can continue using the white list corresponding to region A, or whether the UE's white list should be replaced with the white list corresponding to region B. In other words, the UE's white list for region A may not be honored by the network operator.

[0026] FIG. 3 illustrates a plurality of geographical region borders that are defined based on a combination of location area codes (LACs), routing area codes (RACs) and type allocation codes (TACs). In 3GPP systems, as well as many wireless networks, geographical state borders or national borders may be difficult to distinguish to the mobile equipment. While FIG. 3 illustrates distinct geographical borders, these borders may be served by various cells, e.g., Public Land Mobile Networks (PLMNs) of different countries or regions. Location related features, such as Cell IDs, Location Area Code (LACs), Routing Area Code (RACs) or Type Allocation Codes, Mobile Country Code (MCC) and Mobile Network Code (MNC) are generally not designed to provide an exact geographical mapping of a border. However, a combination of LACs or RACs or TACs may mark or distinguish the state of a country or nation. In other words, grouping LACs or RACs or TACs with similar characteristics or identifiers may infer the geographical region associated with the mobile device. Such national delineation may be regulated, controlled by the nation's regulatory body and be accepted and abided by the operators operating within that nation/country.

[0027] FIG. 4 illustrates a network element communicating a state indicator message (or a regional indicator message) to a user equipment (UE) or a mobile station (MS). The state indicator message may include a current geographical region of the UE (e.g., Utah). The network element may communicate the state indicator message in response to non-access stratum (NAS) registration or

a registration update performed by the UE. The UE may communicate a location updating request message, an attach request message, a routing area update request message, a tracking area update request message, or other types of NAS messages to the network. The network may respond with a location updating accept message, an attach accept message, a routing area update accept message, a tracking area update accept message, or other types of NAS network-to-UE response messages that include an indication of the state indicator. In an alternative configuration, the state indicator or region indicator may be broadcasted in system broadcast information.

[0028] The "state-indicator" may uniquely distinguish a state inside a country using an octet where the 8 bits is a binary decode of states. One octet or eight bits may suffice for the number of states in the United States (i.e., 50 states). In addition, one octet may be sufficient for countries such as Russia with 83 subdivisions, republics and/or territories.

[0029] Although mobile devices generally include global position system (GPS) capabilities to enable the mobile devices to know the state (or sub-region) associated with the mobile devices, such information does not generally indicate whether regional requirements are active. Therefore, GPS information may be used in addition to the state indicator message described above.

[0030] FIG. 5 illustrates Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information included in an exemplary elementary file (EF) communicated to a mobile device. The terms "ACDC/ASAC information" and "ACDC/ASAC applicability and application categories list" as used herein may be used interchangeably. The EF file may be provisioned or pre-provisioned onto the mobile device using OMA-DM or a subscriber identity module toolkit (or SIMToolkit). The use OMA-DM or SIMToolkit for provisioning or pre-provisioning may include indications, means or triggers to allow mobile devices and operators/wireless networks to activate regional requirements and/or roaming requirements. The regional requirements may be activated when the mobile device is in a region that is different than a home region. The term "foreign region" used herein may generally refer to a region of the mobile device that is different than the home region. The foreign region may include a region that is roamed into by the mobile device.

[0031] The ACDC/ASAC information in the EF file may be for a universal subscriber identity module (USIM), a subscriber identity module (SIM) or a universal integrated circuit card (UICC) of the mobile device and communicated to the mobile device using a SIM toolkit. Alternatively, the ACDC/ASAC information may be specified as an Open Mobile Alliance management object (OMA-MO) and communicated to the mobile device using an Open Mobile Alliance Device Management (OMA-DM) protocol. In addition, both an EF file and an OMA-MO may be included during delivery, provisioning and pre-provision-

ing of the ACDC/ASAC information onto the mobile device.

[0032] As previously stated, the ACDC/ASAC information (or the ACDC/ASAC applicability and application categories list) may contain control and management information of ACDC/ASAC and the white listed applications and/or application categories. The list may include a number of indicators, such as whether a region (state or province etc.) of the home country can provide an override to the white listed applications. In other words, the list may indicate whether a network operator in the home region may override the white list currently being implemented at the UE with a new white list. The list may indicate whether a mobile device roaming outside its MCC can take ACDC/ASAC applicable information, such as ACDC/ASAC activation and an ACDC/ASAC preconfigured white list, of the foreign region. In other words, the list may indicate whether the mobile device may adopt the ACDC/ASAC scheme of the foreign region or continue using the ACDC/ASAC scheme that corresponds to the mobile device's home region. An MCC list with specific MCCs (e.g., MCC1, MCC2, MCCa, MCCb) may be included when MMC override is allowed according to the ACDC/ASAC information. In one example, the mobile device may continue to use the previous ACDC/ASAC scheme if the new network operator honors the mobile device's previous ACDC/ASAC.

[0033] The ACDC/ASAC applicability and application categories list may include an indication of prioritization information of the white listed applications or application categories, i.e. whether the provided list of applications or application categories are in a prioritized order. For example, certain application categories (e.g., emergency response applications) may be given a higher priority as compared with other types of application categories (e.g., video sharing applications). The prioritization of ACDC/ASAC applications or application categories may be indicated using a prioritization level that is assigned by the network operator (e.g., N, N+1, N+2, and N+ 3). In addition, the list may include the preconfigured white list of applications or application categories, i.e. the white list of applications and/or application categories that are allowed to access the mobile network when ACDC/ASAC is activated for the network. Although the indicators described above are shown as part of the ACDC/ASAC applicability and application categories list, some or all of these indicators may be separately provided as standalone indicators.

[0034] For applicability of ACDC/ASAC when the mobile device is roaming and a roaming override is allowed, a second list may be generated with the MCCs where the mobile device is roaming that take into account ACDC/ASAC specific and applicable information of the foreign region. Alternatively, the second list may be generated with the MCCs where the mobile device is roaming that do not take into account ACDC/ASAC specific and applicable information of the foreign region.

[0035] In one configuration, more than one list may be

provisioned or pre-provisioned onto the UE. Thus, the network operator may provision X number of lists, wherein each list corresponds to a particular region. Additional information may be included, such as distinguishing the state for which the list is applicable or distinguishing which is the home state of the UE. For example, the wireless network may provide a first list that corresponds to the UE's home region and a second list that corresponds to a foreign region.

[0036] FIG. 6 illustrates a network element communicating Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information in response to receiving a non-access stratum (NAS) message from the UE. The NAS signaling may allow the wireless network to provide the UE with information about certain wireless network or regional conditions in more or less real time. The NAS signaling may utilize 3GPP standardized mechanisms for delivering the ACDC/ASAC applicable dynamic information to the UE. The Network ACDC/ASAC applicable information may be used by itself to fulfill local ACDC requirements or in conjunction with the ACDC information delivered by OMA-DM or the SIM Toolkit

[0037] The network may activate the ACDC/ASAC conditions and the UE may initiate or operate applications or categories of applications according to the ACDC/ASAC conditions. The network may include a network element, such as the MME, ANDSF or a dedicated ACDC/ASAC server. Thus, the action of the ACDC/ASAC conditions may be initiated from the MME via the NAS protocol, the ANDSF through the OMA-DM protocol, or the dedicated ACDC/ASAC server via a hypertext transfer protocol (HTTP) protocol.

[0038] The UE or mobile station (MS) may perform a registration update, e.g., the UE may send a location updating request message, an attach request message, a routing area update request message, a tracking area update request message, or other types of NAS messages to the network. The network may respond with a location updating accept message, an attach accept message, a routing area update accept message, a tracking area update accept message, or other types of NAS network-to-UE response messages that include an indication of the state indicator. The network may accept the service request from the UE by the provision and allocation of radio access bearers (RABs). In addition, the network may provide the UE with the ACDC/ASAC information, as previously described in FIG. 5. The ACDC/ASAC information may be included in a list or an information element (IE) and may contain the necessary ACDC/ASAC applicable information local to the wireless network.

[0039] The network may provide the ACDC/ASAC information (i.e., the ACDC/ASAC applicability and application categories list) to the mobile device either without discrimination or when network knows that the mobile device supports dynamic ACDC/ASAC provisioning/handling. If the mobile device receives the

ACDC/ASAC information and does not support dynamic ACDC/ASAC provisioning/handling, then the mobile device may ignore the ACDC/ASAC information.

[0040] If the mobile device receives the ACDC/ASAC information and does support dynamic ACDC/ASAC provisioning/handling, the mobile device may check its non-real time ACDC/ASAC information and, if allowed to take into account local ACDC/ASAC applicability information, the mobile device may continue with processing the local ACDC/ASAC applicability information. Therefore, the mobile device may check on non-real time ACDC/ASAC information populated by a home network operator (e.g., information from the home network operator indicating whether the mobile device is allowed to adopt a white list associated with a foreign network). In addition, mobile devices roaming in visited networks or foreign networks may be provided local ACDC/ASAC applicability information without having the full complement of non-real time ACDC/ASAC information.

[0041] The ACDC/ASAC information may include indications of prioritization or applications/application categories that are prioritized and therefore allowed when ACDC/ASAC is activated for the corresponding wireless network. The prioritization may be in the order of applications/application categories that are priority 1 or of high priority, applications/application categories that are priority 2 or medium priority, and then applications/application categories on priority 3 or low priority. For example "A" and "B" may have high priority, "X," "Y," and "Z" may have medium priority, and "K" may have low priority. In addition, the ACDC/ASAC information may indicate an allowed number of prioritized applications or application categories when ACDC is active in the wireless network.

[0042] The ACDC/ASAC information may identify the applications or application categories for each priority level (e.g., a priority level of 1, 2 or 3, or a priority level of high, medium or low). The application categories may include social networking applications, online shopping applications, news applications, educational applications, music applications, video streaming applications, and so on. In addition, the categories of applications may share other similarities, such as a category of applications that are most popular among females of ages 13-17. Each application category may include a plurality of specific applications. For example, the application category of music applications may include over a 100 specific music applications. These identified applications may or may not appear on the white list. While the number of identified applications or application categories is not restricted, the nature of the ACDC/ASAC feature is likely to result in a relatively small number of identified applications. In some examples, the network may indicate no applications or a selected number of applications depending on the level of network congestion.

[0043] As an example illustrated by FIG. 6, if ACDC/ASAC is active and the mobile device wants to start App Y and App K, then only App Y is started. Similarly, if the higher layers trigger App X, but App A and

App B are also started, then App X will not be started.

[0044] For the identified applications and/or application categories and their corresponding priority level when ACDC/ASAC is active, the wireless network may indicate a valid time of the given ACDC/ASAC information. The indicated valid time may be an absolute time after which the ACDC/ASAC information is no longer valid. The valid time may indicate a start time and end time, i.e., a range of time. The valid time may indicate a number of seconds, minutes, hours, deci-hours, etc. that the ACDC/ASAC information is valid for since provided to the mobile device. If no valid time is given, the mobile device may consider the ACDC/ASAC valid until a next registration update or an update at a next request for service. When the valid time is still running at the next registration update, the next registration update information may clear out all previously provided ACDC/ASAC information. Unless the wireless network chooses not to update the ACDC/ASAC information (i.e., the ACDC/ASAC applicability and application categories list) in the next registration update, the current or presently available ACDC/ASAC information at the mobile device may continue to be valid.

[0045] For the identified applications and/or application categories and their corresponding priority level when ACDC/ASAC is active, the wireless network may indicate a valid geographical location to which the prioritized list of applications or application categories applies. The valid geographical location may be indicated in any of the 3GPP allowed location identifications, such as LAC, RAC, TAC, or even 3GPP defined Geo-coordinates or commonly described global positioning system (GPS) co-ordinates. Therefore, the prioritized list may not apply when the mobile device is outside of the valid geographical location. If no valid geographical location is given, the mobile device may consider the ACDC/ASAC information valid until a next registration update or update at next request for service. Even if the geographical location is given and the location is still valid at the next registration update, the next registration update information may clear out all previously provided ACDC/ASAC information. The ACDC/ASAC information may be flushed during a change of the Public Land Mobile Network (PLMN), although exceptions may be made when the mobile device changes to equivalent PLMNs (e.g., enhanced PLMNs) or equivalent home PLMNs (e.g., enhanced home HPLMNs).

[0046] In one configuration, the full complement of ACDC/ASAC information may not be implemented using individual network operators. For instance, the "Roaming overwrite" indication may not be adopted, and instead, individual network operators may have provisions in their roaming agreements with fellow network operators to allow or disallow applicability of ACDC/ASAC to the inbound roaming subscribers. Such contractual agreements may still require signaling solutions - as the visited network or foreign network may need to signal to the inbound roamer (i.e., the mobile device that has roamed

to the foreign network) regarding allowed or not allowed applicability of ACDC/ASAC information.

[0047] FIG. 7 illustrates a network element determining that no categories of applications on a preconfigured list of application categories are allowed to operate at a user equipment (UE) when Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) is activated and the UE is roaming outside a home geographical region. In other words, the network element may be in a foreign region (i.e., outside the home region associated with the UE) and does not allow the UE to operate ACDC/ASAC applications when the UE is roaming within the foreign region. The activation of the ACDC/ASAC conditions may be initiated from the MME via the NAS protocol, the ANDSF through the OMA-DM protocol, or the dedicated ACDC/ASAC server via a hypertext transfer protocol (HTTP) protocol.

[0048] When the mobile device performs a registration update, or when the mobile device requests for resources, the wireless network in response to that signaling may indicate a reject cause. The reject cause may indicate to the mobile device that ACDC/ASAC applications or application categories are not allowed when ACDC/ASAC is activated in the wireless network. When the mobile device receives the reject cause, the mobile device upon detecting that ACDC/ASAC is active in the wireless network may not initiate any of the ACDC/ASAC applications or application categories. The restriction may take place even if the UE has an ACDC white list. In addition, the imposition may apply until the next registration update or service update.

[0049] As shown in FIG. 7, the UE may communicate a location updating request message, an attach request message, a routing area update request message, a tracking area update request message, or other types of NAS messages to the network. The network may respond with a location updating reject message, an attach reject message, a routing area update reject message, a tracking area update reject message, or a service reject message. Alternatively, the network may respond with a service accept message with a reject cause, wherein the reject cause indicates that ACDC applications are not allowed when ACDC/ASAC is activated in the wireless network.

[0050] The registration updates may be accepted with a location updating accept message, an attach accept message, a routing area update accept message, a tracking area update accept message, or a service accept message and resources may be provided, but a reject cause may also be provided with these messages indicating that ACDC/ASAC applications are not allowed when ACDC/ASAC is active.

[0051] FIG. 8 illustrates a network element determining that no categories of applications on a preconfigured list of application categories are allowed to operate at a user equipment (UE) when the UE is roaming outside a home geographical region and regardless of whether Applica-

tion Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) is activated. In other words, the network element may be within a foreign region and does not allow the UE to operate ACDC/ASAC applications when the UE is roaming within the foreign region. The activation of the ACDC/ASAC conditions may be initiated from the MME via the NAS protocol, the ANDSF through the OMA-DM protocol, or the dedicated ACDC/ASAC server via a hypertext transfer protocol (HTTP) protocol.

[0052] When the mobile device performs a registration update, or when the mobile device requests for resources, the network may respond with a reject cause indicating to the mobile device (i.e., an inbound roamer) that ACDC/ASAC applications are not allowed on a roaming UE. When the mobile device receives the reject clause, the mobile device may not initiate any of the ACDC/ASAC applications or application categories, regardless of whether ACDC/ASAC is active in the wireless network. The restriction may apply when UE has an ACDC white list and can be applicable until the next registration update or service update.

[0053] As shown in FIG. 8, the UE may communicate a location updating request message, an attach request message, a routing area update request message, a tracking area update request message, or other types of NAS messages to the network. The network may respond with a location updating reject message, an attach reject message, a routing area update reject message, a tracking area update reject message, or a service reject message. Alternatively, the network may respond with a service accept message with a reject cause, wherein the reject cause indicates that ACDC applications are not allowed when the UE is roaming.

[0054] The network may accept the registration updates and indicate that the ACDC/ASAC applications or application categories are not allowed when ACDC/ASAC is active. The registration updates may be accepted with a location updating accept message, an attach accept message, a routing area update accept message, a tracking area update accept message, or a service accept message and resources may be provided, but a reject cause may also be provided with these messages indicating that ACDC/ASAC applications are not allowed when the UE is roaming.

[0055] FIG. 9 illustrates a network element communicating Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information to a user equipment (UE) indicating whether applications on a preconfigured list of application categories are allowed to operate at the UE when the UE is roaming outside a home geographical region and ACDC/ASAC is activated. The activation of the ACDC/ASAC conditions may be initiated from the MME via the NAS protocol, the ANDSF through the OMA-DM protocol, or the dedicated ACDC/ASAC server via a hypertext transfer protocol (HTTP) protocol.

[0056] The network may allow the mobile device (i.e.,

the inbound roamer) to operate ACDC/ASAC applications or categories of ACDC/ASAC applications. When the mobile device performs a registration update, or when the mobile device requests for resources, the network may respond by indicating that ACDC/ASAC applications are allowed when the UE is roaming subject to the activation of ACDC/ASAC in the network. When the mobile device receives the indication that ACDC/ASAC applications are allowed when the UE is roaming, the mobile device may know that ACDC/ASAC applications indicated in the home public land mobile network (HPLMN) provisioned white list may be run when ACDC/ASAC is active in the visited public land mobile network (VPLMN).

[0057] As shown in FIG. 9, the UE may communicate a location updating request message, an attach request message, a routing area update request message, a tracking area update request message, or any other type or level of signaling messages between UE and the network. The network may determine no ACDC restrictions for the UE. The network may respond with a location updating accept message, an attach accept message, a routing area update accept message, a tracking area update accept message, or a service accept message (or any other type or level of signaling message), wherein these messages indicate that ACDC/ASAC applications are allowed when the UE is roaming.

[0058] In one configuration, the ACDC/ASAC white list in the UE may be updated using paging messages and a System Information Block (SIB). The UE may be updated using the paging message and SIB in Universal Terrestrial Radio Access Network (UTRAN) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN) systems. An evolved node B (eNB) may communicate an ACDC/ASAC whitelist notification in the paging message to the UE. The ACDC/ASAC whitelist notification may notify the UE that an ACDC/ASAC SIB is being broadcast by the eNB.

[0059] The ACDC/ASAC whitelist notification may include an ACDC/ASAC Group ID (i.e. group of UEs for which the ACDC/ASAC white list applies). If an ACDC/ASAC Group ID is included, only mobile devices belonging to the corresponding ACDC/ASAC group may need to acquire the ACDC/ASAC SIB. If an ACDC/ASAC Group ID is not included, all devices configured for ACDC/ASAC may acquire the ACDC/ASAC SIB. In a LTE system, the scheduling information of the ACDC/ASAC SIB may be provided in a system information block type 1 (SIB1). The mobile device configured for ACDC/ASAC may first acquire the SIB1 information and then subsequently acquire the ACDC/ASAC SIB based on ACDC/ASAC SIB scheduling information included in the SIB1.

[0060] Therefore, the SIB may include an indication of whether ACDC/ASAC is active in the wireless network. Additional information may be sent over the SIBs to selected groups or collections of mobile devices. The additional information may include indications in the form of specific ranges of international mobile subscriber iden-

titles (IMSI), temporary mobile subscriber identities (TMSIs), globally unique temporary identifiers (GUTIs) or other 3GPP unique identifiers of mobile equipment or mobile subscriptions or mobile users.

[0061] The additional information may include indications of specific categories of mobile devices. The specific categories of mobile devices may be in any form of new identity or previously defined identity, such as an access class of the mobile device. The network, broadcast subsystem, and the mobile device may all share the same understanding of the specific categories. For instance, the wireless network may not use power class as a categorization, while the mobile devices use access class as the categorization. In other words, both sides of the radio interface may use the same categorization. Although a number of different (new or existing) categories may be adopted, generally only one category is used at any given time. Thus, apart from broadcasting the category of mobile devices affected by the activation of ACDC/ASAC, the wireless network may indicate which category is to be used as the selective criteria.

[0062] In one example, the SIB may indicate that if ACDC/ASAC is active in the wireless network, whether the ACDC/ASAC is applicable to inbound roamers without exceptions. In other words, the inbound roamers may include UEs that are roaming in a foreign region and are outside the UE's home region.

[0063] In one example, the SIB may indicate that if ACDC/ASAC is active in the wireless network, whether the ACDC/ASAC is applicable to inbound roamers with exceptions. These exceptions may be identified based on Public Land Mobile Networks identifiers (PLMN IDs), ranges of PLMN IDs, Mobile Country Codes (MCCs), or ranges of MCCs with such exceptions. In other words, the PLMN IDs and MCCs that are not identified are not exempted. Alternatively, these exceptions may be identified based on PLMN IDs, ranges of PLMN IDs, MCCs, or ranges of MCCs without exceptions. In other words, the PLMN IDs and MCCs that are not identified are exempted. In addition, the identification of specific categories may provide finer granularity when selecting the mobile devices that are or are not to follow the applicability of ACDC in the wireless network.

[0064] The information described above may be provided to the mobile device over the SIBs or other selected 3GPP broadcast techniques. The mobile device may use to broadcast information to know if the mobile device belongs to the specific category that is being broadcasted. Even if the category has been previously defined by 3GPP, the mobile device may determine whether the mobile device's identity matches with the category that was broadcasted over the SIBs.

[0065] The UE may be provided with information indicating that a new categorization has been specified. In one example, the mobile device's SIM/USIM may be pre-provisioned with the identity/information of its category. The mobile may also receive the identity/information of its category via SMS provisioning or through OMA DM.

If the UE knows its category and if that category matches with the category that is broadcasted over the SIB with respect to ACDC/ASAC, then what is applicable for ACDC/ASAC as indicated over the SIB may apply for the mobile device and the mobile device may act accordingly. Such ACDC/ASAC applicable information on the mobile device may be based on home operator policies and may be home operator configurable subjecting the UE to roamed to (i.e., visited) PLMN's allowance/activation of ACDC/ASAC. Such information may be configured as part of mobile configuration information (i.e. on SIM/USIM) and may include indications to guide the roaming mobile device to utilize Visited networks ACDC/ASAC activation information over the SIBs or broadcast messages/information. In addition, the mobile device may be subjected to ACDC based on the configuration of ACDC in the mobile device using OTA provisioning techniques, such as USIM-OTA or OMA-DM.

[0066] Another example provides functionality 1000 of computer circuitry of a wireless network element operable to provision categories of applications on a mobile device, as shown in the flow chart in FIG. 10. The functionality may be implemented as a method or the functionality may be executed as instructions on a machine, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The computer circuitry can be configured to communicate Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information to the mobile device, the ACDC/ASAC information including a preconfigured white list of application categories containing categories of applications that are allowed to access the wireless network when ACDC/ASAC is activated in the wireless network, as in block 1010. The computer circuitry can be configured to detect that a wireless network channel condition of the wireless network exceeds a capacity threshold, as in block 1020. The computer circuitry can be further configured to activate the ACDC/ASAC at a selected prioritization level while the capacity threshold is exceeded, the ACDC/ASAC enabling only categories of applications contained in the pre-configured white list to operate at the mobile device, as in block 1030.

[0067] In one configuration, the ACDC/ASAC information may indicate whether the preconfigured white list of application categories is capable of being overridden by a home geographical region associated with the mobile device. In addition, the ACDC/ASAC information may indicate whether the mobile device is able to receive the ACDC/ASAC information for a geographical region that is outside a mobile country code (MCC) associated with the mobile device when the mobile device is roaming within the geographical region.

[0068] In one example, the ACDC/ASAC information may indicate that the applications in the preconfigured white list of application categories are valid for a defined period of time when the ACDC/ASAC is active in the wire-

less network. In addition, the ACDC/ASAC information may indicate one or more geographical locations where the preconfigured white list of application categories applies to the mobile device when the ACDC/ASAC is active in the wireless network. In one example, the wireless network element may include an Access Network Discovery and Selection Function (ANDSF) and the ANDSF communicates the ACDC/ASAC information to the mobile device using an Open Mobile Alliance Device Management (OMA-DM) protocol. Furthermore, the wireless network element may include an ACDC/ASAC server and the ACDC/ASAC server communicates the ACDC/ASAC information to the mobile device via a hypertext transfer protocol (HTTP) protocol.

[0069] In one configuration, the computer circuitry can be further configured to communicate the ACDC/ASAC information to the mobile device in response to receiving at least one of: a location updating request message, an attach request message, a routing area update request message, a tracking area update request message, or a service request message from the mobile device. In addition, the computer circuitry can be further configured to communicate a state indicator to the mobile device indicating a geographical region associated with the mobile device.

[0070] In one example, the ACDC/ASAC information may be included in an elementary file (EF) for one of a universal subscriber identity module (USIM), a subscriber identity module (SIM) or a universal integrated circuit card (UICC) of the mobile device. The EF may be communicated to the mobile device using a SIM toolkit. In addition, the ACDC/ASAC information may be specified as an Open Mobile Alliance management object (OMA-MO) and communicated to the mobile device using an Open Mobile Alliance Device Management (OMA-DM) protocol.

[0071] In one configuration, the computer circuitry can be further configured to communicate a reject cause in the ACDC/ASAC information to the mobile device, the reject cause indicating that none of the applications in the preconfigured list of application categories are allowed to operate at the mobile device when ACDC/ASAC is activated in the wireless network and the mobile device is roaming outside a home geographical region. In addition, the computer circuitry can be further configured to communicate a reject cause in the ACDC/ASAC information to the mobile device, the reject cause indicating that none of the applications in the preconfigured list of application categories are allowed to operate at the mobile device when the mobile device is roaming outside a home geographical region and regardless of whether ACDC/ASAC is activated in the wireless network.

[0072] In one example, the computer circuitry can be further configured to communicate ACDC/ASAC information to the mobile device indicating that the preconfigured list of application categories are allowed to be operate at the mobile device when the mobile device is roaming outside a home geographical region and

ACDC/ASAC is activated in the wireless network. In addition, the ACDC/ASAC information may include a plurality of preconfigured white lists of application categories that correspond to a plurality of geographical regions and the wireless network element activates at least one of the preconfigured white lists of application categories when the mobile device roams through the geographical regions. Furthermore, the preconfigured white list of application categories in the ACDC/ASAC information may correspond to a home geographical region associated with the mobile device and the wireless network element communicates additional preconfigured white lists of application categories when the mobile device roams outside the home geographical region.

[0073] Another example provides functionality 1100 of computer circuitry of a user equipment (UE) operable to operate applications according to a preconfigured white list of prioritized application categories, as shown in the flow chart in FIG. 11. The functionality may be implemented as a method or the functionality may be executed as instructions on a machine, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The computer circuitry can be configured to communicate a registration update message to a wireless network element, as in block 1110. The computer circuitry can be configured to receive Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information from the wireless network element in response to communicating the registration update message, the ACDC/ASAC information including the preconfigured white list of prioritized application categories, as in block 1120. The computer circuitry can be further configured to operate only applications contained in the preconfigured white list of prioritized application categories when ACDC/ASAC is activated in a wireless network, the ACDC/ASAC being activated in response to a wireless network channel condition of the wireless network exceeding a capacity threshold, as in block 1130.

[0074] In one configuration, the computer circuitry can be further configured to receive an updated preconfigured white list of prioritized application categories from the wireless network element when the wireless network does not exceed the capacity threshold. In addition, the computer circuitry can be configured to receive an ACDC/ASAC white list notification in a paging message from an evolved node B (eNB) to notify the UE that an ACDC/ASAC system information block (SIB) is being broadcast at the eNB. The computer circuitry can be further configured to receive the ACDC/ASAC SIB from the eNB after receiving a SIB type 1 (SIB1) from the wireless network element, the UE receiving the ACDC/ASAC SIB according to ACDC/ASAC SIB scheduling information included in the SIB1 and the ACDC/ASAC SIB including updated white list information.

[0075] In one example, the ACDC/ASAC SIB indicates whether ACDC/ASAC is active in the wireless network,

and if ACDC/ASAC is active, whether the ACDC/ASAC is applicable to inbound roamers with exceptions or whether ACDC/ASAC is applicable to inbound roamers without exceptions. In addition, the ACDC/ASAC SIB includes additional information that is sent to a selected group of mobile devices, wherein the additional information indicates specific categories of mobile devices, wherein the additional information indicates specific ranges of international mobile subscriber identities (IM-SIs), temporary mobile subscriber identities (TMSIs), and globally unique temporary identifiers (GUTIs). In one example, the UE includes an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, internal memory, or a non-volatile memory port.

[0076] Another example provides a method 1200 for provisioning categories of applications on a user equipment (UE), as shown in the flow chart in FIG. 12. The method may be executed as instructions on a machine, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The method includes the operation of receiving a registration update message at a wireless network element from the UE over non-access stratum (NAS) signaling, as in block 1210. The method can include communicating Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information from the wireless network element to the UE in response to receiving the registration update message, as in block 1220. The method can further include activating the ACDC/ASAC at a selected prioritization level, at the wireless network element, while a wireless network channel condition of a wireless network exceeds a capacity threshold, the ACDC/ASAC enabling only categories of applications to operate at the UE that are contained in the ACDC/ASAC information, as in block 1230.

[0077] In one configuration, the ACDC/ASAC information may include a preconfigured white list of prioritized application categories that are allowed to access the wireless network when ACDC/ASAC is activated in the wireless network. In one example, the ACDC/ASAC information may indicate: a defined period of time for which prioritized applications in the preconfigured white list are valid when the ACDC/ASAC is active in the wireless network; or a geographical location where the preconfigured white list of prioritized application categories applies to the UE when the ACDC/ASAC is active in the wireless network. Furthermore, the ACDC/ASAC information may indicate whether the preconfigured white list of prioritized application categories is capable of being overridden by a home geographical region associated with the mobile device; or whether the mobile device is able to receive the ACDC/ASAC information for a geographical region that is outside a mobile country code (MCC) associated with the mobile device when the mobile device is roaming within the geographical region.

[0078] FIG. 13 provides an example illustration of the

wireless device, such as an user equipment (UE), a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The wireless device can include one or more antennas configured to communicate with a node, macro node, low power node (LPN), or, transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), or other type of wireless wide area network (WWAN) access point. The wireless device can be configured to communicate using at least one wireless communication standard including 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The wireless device can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The wireless device can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN.

[0079] FIG. 13 also provides an illustration of a microphone and one or more speakers that can be used for audio input and output from the wireless device. The display screen may be a liquid crystal display (LCD) screen, or other type of display screen such as an organic light emitting diode (OLED) display. The display screen can be configured as a touch screen. The touch screen may use capacitive, resistive, or another type of touch screen technology. An application processor and a graphics processor can be coupled to internal memory to provide processing and display capabilities. A non-volatile memory port can also be used to provide data input/output options to a user. The non-volatile memory port may also be used to expand the memory capabilities of the wireless device. A keyboard may be integrated with the wireless device or wirelessly connected to the wireless device to provide additional user input. A virtual keyboard may also be provided using the touch screen.

[0080] Various techniques, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, non-transitory computer readable storage medium, or any other machine-readable storage medium wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the various techniques. Circuitry can include hardware, firmware, program code, executable code, computer instructions, and/or software. A non-transitory computer readable storage medium can be a computer readable storage medium that does not include signal. In the case of program code execution on programmable computers, the computing device may include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. The volatile and non-volatile memory and/or storage elements may be a RAM, EPROM, flash drive, optical

drive, magnetic hard drive, solid state drive, or other medium for storing electronic data. The node and wireless device may also include a transceiver module, a counter module, a processing module, and/or a clock module or timer module. One or more programs that may implement or utilize the various techniques described herein may use an application programming interface (API), reusable controls, and the like. Such programs may be implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) may be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

[0081] It should be understood that many of the functional units described in this specification have been labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom VLSI circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[0082] Modules may also be implemented in software for execution by various types of processors. An identified module of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module.

[0083] Indeed, a module of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network. The modules may be passive or active, including agents operable to perform desired functions.

[0084] Reference throughout this specification to "an example" means that a particular feature, structure, or characteristic described in connection with the example is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in an example" in various places throughout this specification are not necessarily all referring to the same embodiment.

[0085] As used herein, a plurality of items, structural

elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present invention may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as defacto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

[0086] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided, such as examples of layouts, distances, network examples, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, layouts, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

[0087] While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

[0088] The invention may also be defined according to one of the following exemplifying aspects and embodiments.

[0089] According to a first aspect of the invention, a wireless network element operable to provision categories of applications on a mobile device is defined, the wireless network element having computer circuitry configured to communicate Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information to the mobile device, the ACDC/ASAC information including a preconfigured white list of application categories containing categories of applications that are allowed to access the wireless network when ACDC/ASAC is activated in the wireless network, detect that a wireless network channel condition of the wireless network exceeds a capacity threshold, and activate the ACDC/ASAC at a selected prioritization level while the capacity threshold is exceeded, the ACDC/ASAC enabling only categories of applications contained in the preconfigured white list to

operate at the mobile device.

[0090] In one embodiment of the first aspect, the ACDC/ASAC information indicates whether the preconfigured white list of application categories is capable of being overridden by a home geographical region associated with the mobile device.

[0091] According to one embodiment of the first aspect, the ACDC/ASAC information indicates whether the mobile device is able to receive the ACDC/ASAC information for a geographical region that is outside a mobile country code (MCC) associated with the mobile device when the mobile device is roaming within the geographical region.

[0092] In one embodiment of the first aspect, the ACDC/ASAC information indicates that the applications in the preconfigured white list of application categories are valid for a defined period of time when the ACDC/ASAC is active in the wireless network.

[0093] According to one embodiment of the first aspect, the ACDC/ASAC information indicates one or more geographical locations where the preconfigured white list of application categories applies to the mobile device when the ACDC/ASAC is active in the wireless network.

[0094] In one embodiment of the first aspect, the wireless network element includes an Access Network Discovery and Selection Function (ANDSF) and the ANDSF communicates the ACDC/ASAC information to the mobile device using an Open Mobile Alliance Device Management (OMA-DM) protocol.

[0095] According to one embodiment of the first aspect, the wireless network element includes an ACDC/ASAC server and the ACDC/ASAC server communicates the ACDC/ASAC information to the mobile device via a hypertext transfer protocol (HTTP) protocol.

[0096] In one embodiment of the first aspect, the computer circuitry is further configured to communicate the ACDC/ASAC information to the mobile device in response to receiving at least one of: a location updating request message, an attach request message, a routing area update request message, a tracking area update request message, or a service request message from the mobile device.

[0097] According to one embodiment of the first aspect, the computer circuitry is further configured to communicate a state indicator to the mobile device indicating a geographical region associated with the mobile device.

[0098] In one embodiment of the first aspect, the ACDC/ASAC information is included in an elementary file (EF) for one of a universal subscriber identity module (USIM), a subscriber identity module (SIM) or a universal integrated circuit card (UICC) of the mobile device.

[0099] According to one embodiment of the first aspect, the EF is communicated to the mobile device using a SIM toolkit.

[0100] In one embodiment of the first aspect, the ACDC/ASAC information is specified as an Open Mobile Alliance management object (OMA-MO) and communicated to the mobile device using an Open Mobile Alliance

Device Management (OMA-DM) protocol.

[0101] According to one embodiment of the first aspect, the computer circuitry is further configured to communicate a reject cause in the ACDC/ASAC information to the mobile device, the reject cause indicating that none of the applications in the preconfigured list of application categories are allowed to operate at the mobile device when ACDC/ASAC is activated in the wireless network and the mobile device is roaming outside a home geographical region.

[0102] In one embodiment of the first aspect, the computer circuitry is further configured to communicate a reject cause in the ACDC/ASAC information to the mobile device, the reject cause indicating that none of the applications in the preconfigured list of application categories are allowed to operate at the mobile device when the mobile device is roaming outside a home geographical region and regardless of whether ACDC/ASAC is activated in the wireless network.

[0103] According to one embodiment of the first aspect, the computer circuitry is further configured to communicate ACDC/ASAC information to the mobile device indicating that the preconfigured list of application categories are allowed to be operate at the mobile device when the mobile device is roaming outside a home geographical region and ACDC/ASAC is activated in the wireless network.

[0104] In one embodiment of the first aspect, the ACDC/ASAC information includes a plurality of preconfigured white lists of application categories that correspond to a plurality of geographical regions and the wireless network element activates at least one of the preconfigured white lists of application categories when the mobile device roams through the geographical regions.

[0105] According to one embodiment of the first aspect, the preconfigured white list of application categories in the ACDC/ASAC information corresponds to a home geographical region associated with the mobile device and the wireless network element communicates additional preconfigured white lists of application categories when the mobile device roams outside the home geographical region.

[0106] According to a second aspect of the invention, a user equipment (UE) operable to operate applications according to a preconfigured white list of prioritized application categories is defined, the UE having computer circuitry configured to communicate a registration update message to a wireless network element, receive Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information from the wireless network element in response to communicating the registration update message, the ACDC/ASAC information including the preconfigured white list of prioritized application categories, and operate only applications contained in the preconfigured white list of prioritized application categories when ACDC/ASAC is activated in a wireless network, the ACDC/ASAC being activated in response to a wire-

less network channel condition of the wireless network exceeding a capacity threshold.

[0107] In one embodiment of the second aspect, the computer circuitry is further configured to receive an updated preconfigured white list of prioritized application categories from the wireless network element when the wireless network does not exceed the capacity threshold.

[0108] According to one embodiment of the second aspect, the computer circuitry is further configured to receive an ACDC/ASAC white list notification in a paging message from an evolved node B (eNB) to notify the UE than an ACDC/ASAC system information block (SIB) is being broadcast at the eNB.

[0109] In one embodiment of the second aspect, the computer circuitry is further configured to receive the ACDC/ASAC SIB from the eNB after receiving a SIB type 1 (SIB1) from the wireless network element, the UE receiving the ACDC/ASAC SIB according to ACDC/ASAC SIB scheduling information included in the SIB1 and the ACDC/ASAC SIB including updated white list information.

[0110] According to one embodiment of the second aspect, the ACDC/ASAC SIB indicates whether ACDC/ASAC is active in the wireless network, and if ACDC/ASAC is active, whether the ACDC/ASAC is applicable to inbound roamers with exceptions or whether ACDC/ASAC is applicable to inbound roamers without exceptions.

[0111] In one embodiment of the second aspect, the ACDC/ASAC SIB includes additional information that is sent to a selected group of mobile devices, wherein the additional information indicates specific categories of mobile devices, wherein the additional information indicates specific ranges of international mobile subscriber identities (IMSI), temporary mobile subscriber identities (TMSIs), and globally unique temporary identifiers (GUTIs).

[0112] According to one embodiment of the second aspect, the UE includes an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, internal memory, or a non-volatile memory port.

[0113] According to a third aspect of the invention, a method for provisioning categories of applications on a user equipment (UE) is defined, the method comprising receiving a registration update message at a wireless network element from the UE over non-access stratum (NAS) signaling, communicating Application Specific Congestion Control for Data Communications (ACDC)/Application and Service Access Control (ASAC) information from the wireless network element to the UE in response to receiving the registration update message, activating the ACDC/ASAC at a selected prioritization level, at the wireless network element, while a wireless network channel condition of a wireless network exceeds a capacity threshold, the ACDC/ASAC enabling only categories of applications to operate at the UE that are contained in the ACDC/ASAC information.

[0114] In one embodiment of the third aspect, the ACDC/ASAC information includes a preconfigured white list of prioritized application categories that are allowed to access the wireless network when ACDC/ASAC is activated in the wireless network.

[0115] According to one embodiment of the third aspect, the ACDC/ASAC information indicates a defined period of time for which prioritized applications in the preconfigured white list are valid when the ACDC/ASAC is active in the wireless network, or a geographical location where the preconfigured white list of prioritized application categories applies to the UE when the ACDC/ASAC is active in the wireless network.

[0116] In one embodiment of the third aspect, the ACDC/ASAC information indicates whether the preconfigured white list of prioritized application categories is capable of being overridden by a home geographical region associated with the mobile device, or whether the mobile device is able to receive the ACDC/ASAC information for a geographical region that is outside a mobile country code (MCC) associated with the mobile device when the mobile device is roaming within the geographical region.

Claims

1. An apparatus of a network element configured to apply Application Specific Congestion Control for Data Communication (ACDC) in a wireless network, the apparatus comprising:

one or more processors configured to:

determine, at the network element, to apply ACDC in the wireless network to mitigate overload of the wireless network; and process, at the network element, barring information for one or more ACDC categories for transmission to a user equipment (UE) when ACDC is applied in the wireless network, wherein the barring information indicates that the UE is prevented from accessing the network for applications associated with the one or more ACDC categories when ACDC is applied in the wireless network; and memory configured to store the one or more ACDC categories and an indication of the applications included in the one or more ACDC categories.

2. The apparatus of claim 1, further comprising a transceiver configured to broadcast the barring information for the one or more ACDC categories when ACDC is applied in the wireless network.
3. The apparatus of claim 1, wherein the one or more

processors are configured to process one or more ACDC categories for transmission to the UE, wherein a highest ACDC category is associated with applications that are least likely to be restricted at the UE and a lowest ACDC category is associated with applications that are most likely to be restricted at the UE.

4. The apparatus of claim 1, wherein the one or more processors are configured to process at least four ACDC categories for transmission to the UE.
5. The apparatus of claim 1, wherein the one or more processors are configured to apply ACDC to mitigate overload in one or more of a radio access network (RAN) or a core network (CN).
6. The apparatus of claim 1, wherein the one or more processors are configured to process the barring information for the one or more ACDC categories for transmission to a roaming UE within the wireless network.
7. The apparatus of claim 1, wherein the network element is included in a Universal Terrestrial Radio Access Network (UTRAN) or an Evolved Universal Terrestrial Radio Access Network (E-UTRAN).
8. The apparatus of claim 1, wherein the applications associated with the one or more ACDC categories include operator-identified applications.
9. The apparatus of claim 1, wherein the one or more processors are configured to determine to apply ACDC in the wireless network to mitigate overload of the wireless network based on a congestion level.
10. An apparatus of a user equipment (UE) operable to control network access of applications when Application Specific Congestion Control for Data Communication (ACDC) is applied in a wireless network, the apparatus comprising:

one or more processors configured to:

process, at the UE, barring information for one or more ACDC categories received from a network element when ACDC is applied in the wireless network, wherein the barring information indicates to the UE that applications associated with the one or more ACDC categories are prevented at the UE from accessing the network element when ACDC is applied in the wireless network; and
prevent, at the UE, the applications included in the one or more ACDC categories indicated in the barring information from ac-

cessing the network element when ACDC is applied in the wireless network; and
memory configured to store the one or more ACDC categories and an indication of the applications included in the one or more ACDC categories.

11. The apparatus of claim 10, wherein the one or more processors are configured to process a configuration with one or more ACDC categories received from the network element, wherein the configuration indicates that a highest ACDC category is associated with applications that are least likely to be restricted at the UE and a lowest ACDC category is associated with applications that are most likely to be restricted at the UE.
12. The apparatus of claim 10, wherein the one or more processors are configured to process the barring information for the one or more ACDC categories received from the network element when the UE is roaming within the wireless network.
13. At least one non-transitory machine readable storage medium comprising instructions embodied thereon, the instructions when executed by one or more processors of a network element cause the network element to perform the following:

determining, at the network element, to apply Application Specific Congestion Control for Data Communication (ACDC) in a wireless network to mitigate overload of the wireless network; and
processing, at the network element, barring information for one or more ACDC categories for transmission to a user equipment (UE) when ACDC is applied in the wireless network, wherein the barring information indicates to the UE that applications associated with the one or more ACDC categories are prevented at the UE from accessing the network element when ACDC is applied in the wireless network.
14. The at least one non-transitory machine readable storage medium of claim 13, further comprising instructions which when executed by the one or more processors cause the network element to perform the following: configuring the UE with one or more ACDC categories, wherein a highest ACDC category is associated with applications that are least likely to be restricted at the UE and a lowest ACDC category is associated with applications that are most likely to be restricted at the UE.
15. The at least one non-transitory machine readable storage medium of claim 13, further comprising instructions which when executed by the one or more processors cause the network element to perform

the following: applying ACDC to mitigate overload in one or more of a radio access network (RAN) or a core network (CN).

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Applications (or Application Categories)	Option 1	Option 2
A	N	N
B	N	N+1
C	N+1	N+2
D	N+1	N+3
E	N+2	N+4
F	N+2	N+5
G	N+3	N+6
H	N+3	N+7

FIG. 1A

Applications (or Application Categories)	Priority Level	Allowed During Condition Level #
A	N	N, N+1, N+2, N+3
B	N	N, N+1, N+2, N+3
C	N+1	N+1, N+2, N+3
D	N+1	N+1, N+2, N+3
E	N+2	N+2, N+3
F	N+2	N+2, N+3
G	N+3	N+3
H	N+3	N+3

FIG. 1B

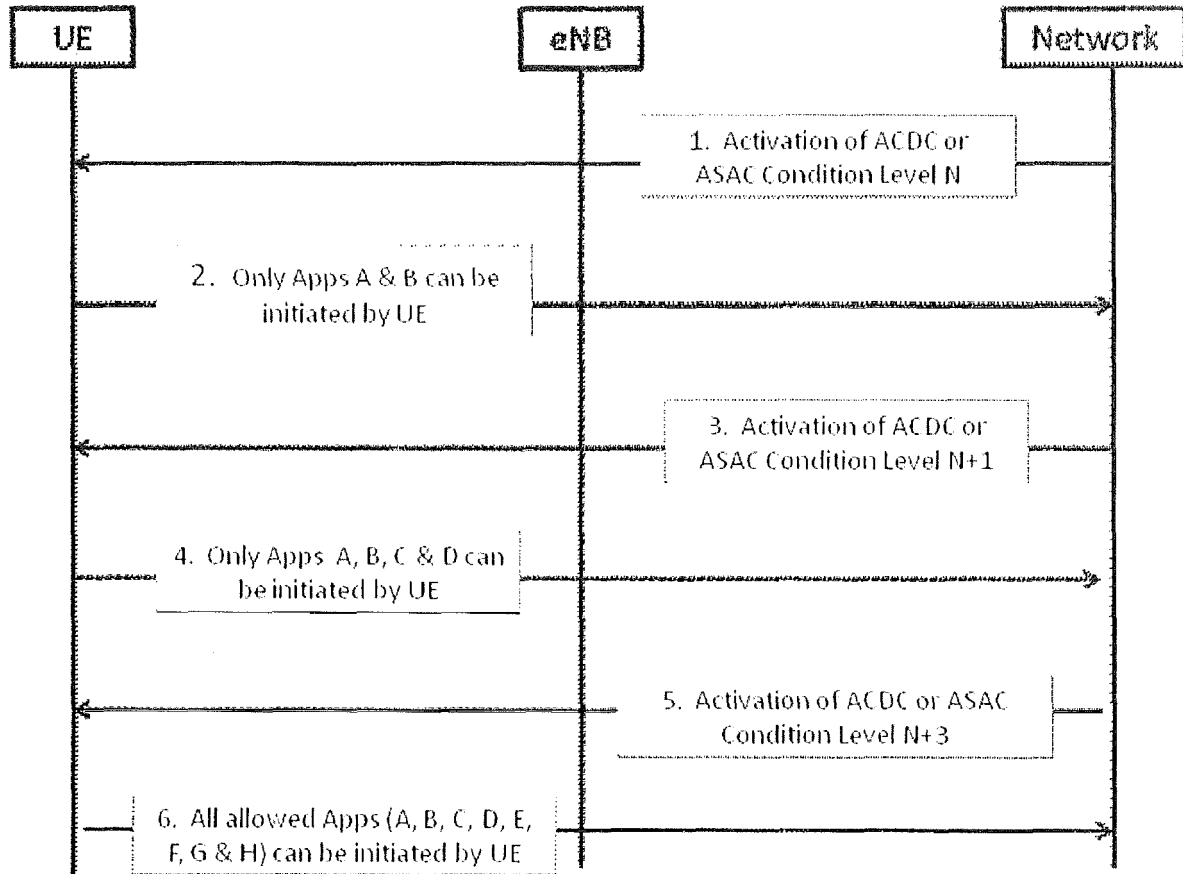


FIG. 2

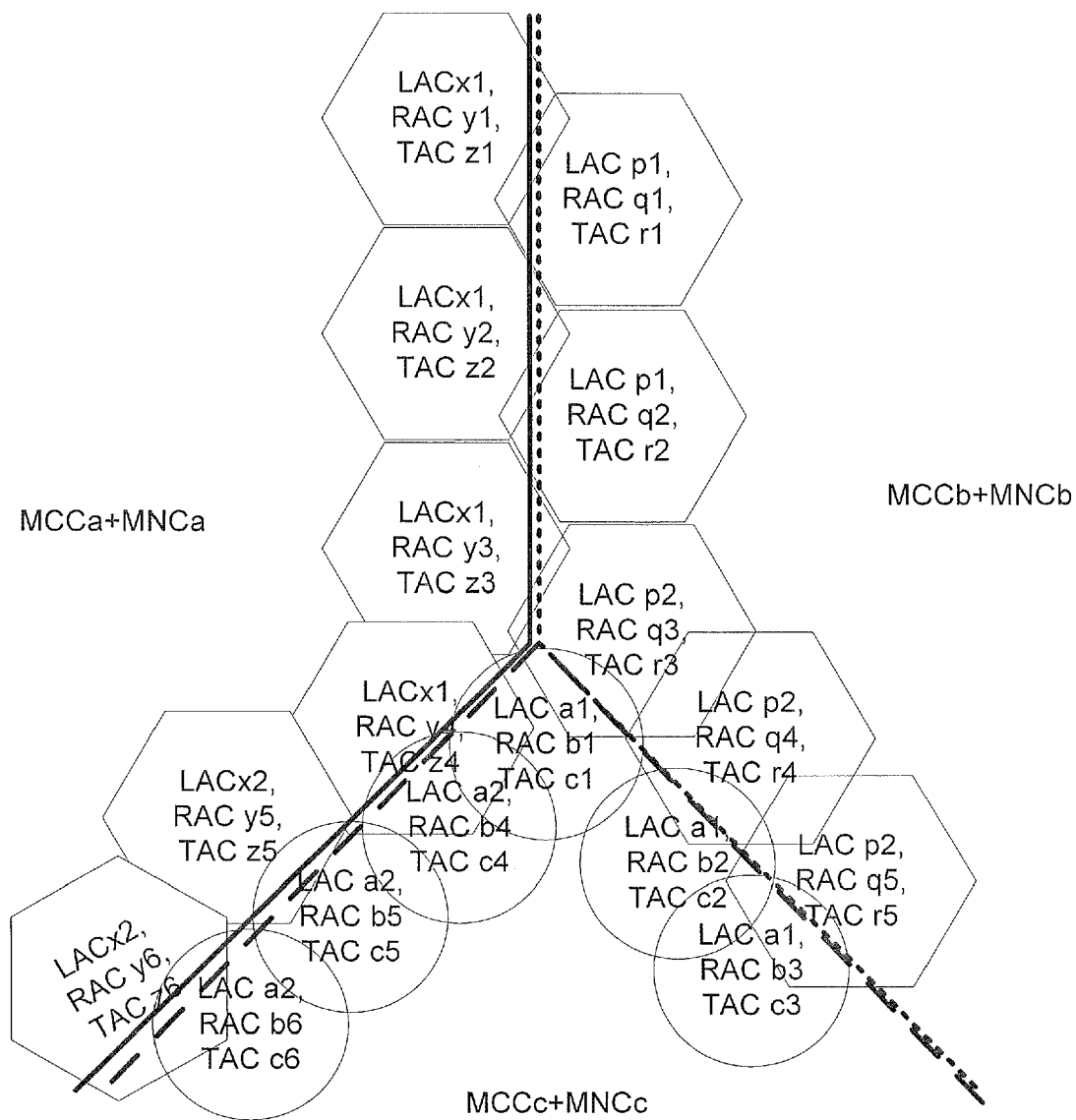


FIG. 3

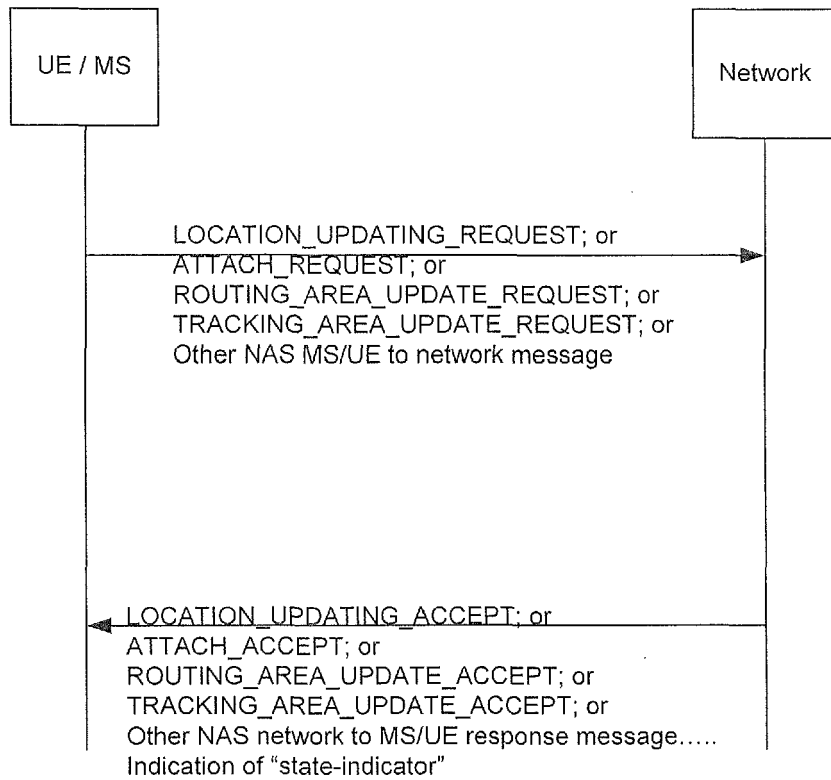


FIG. 4

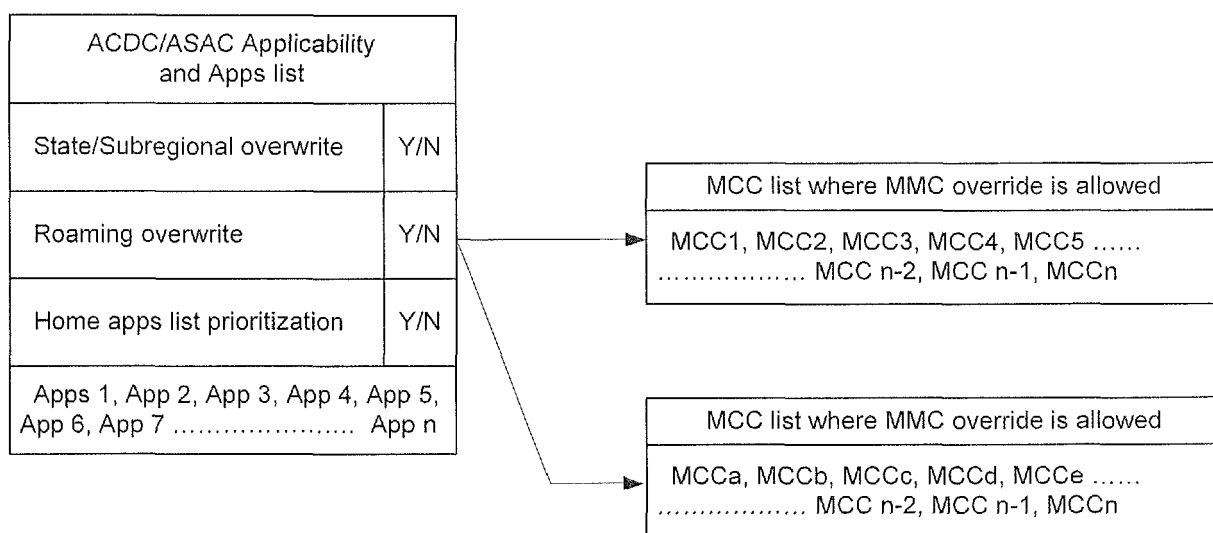


FIG. 5

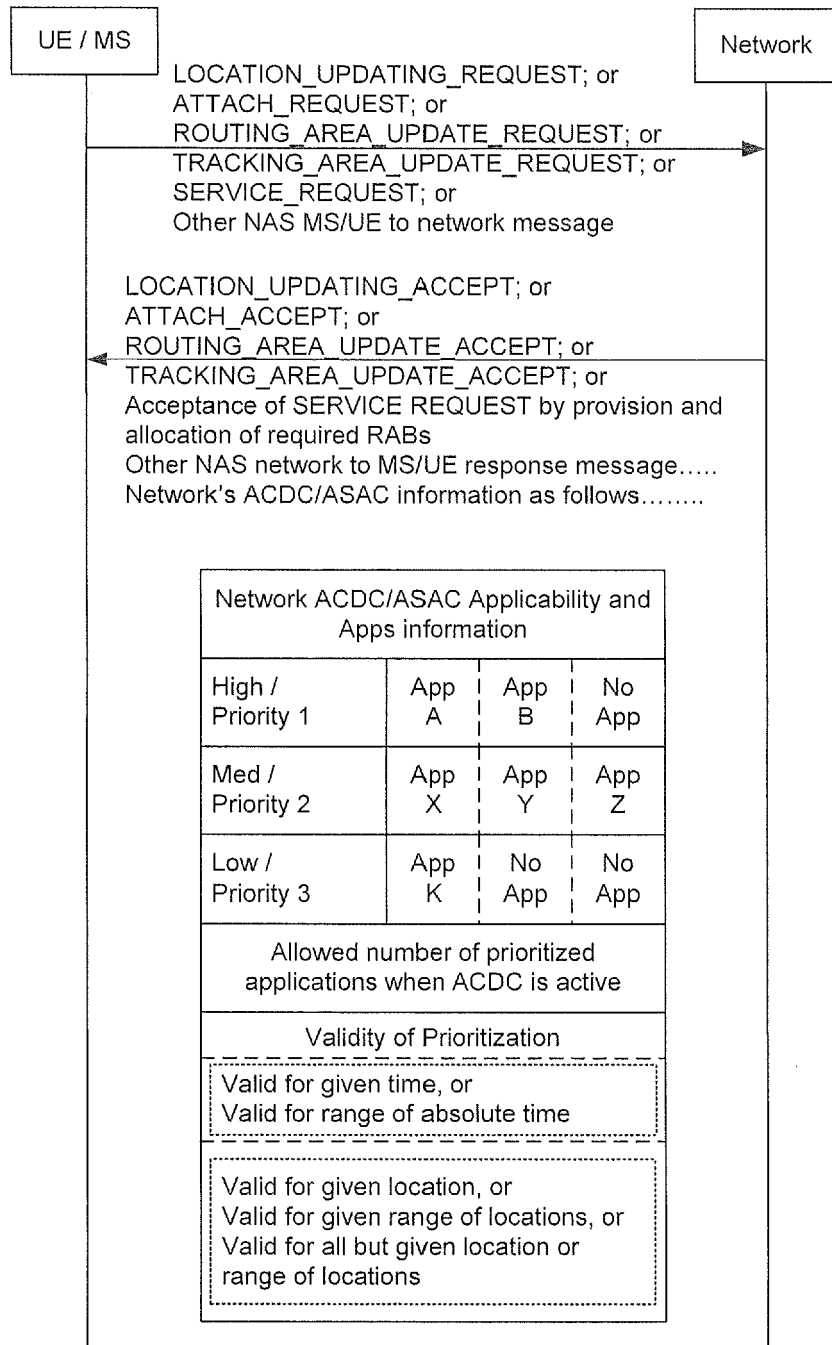


FIG. 6

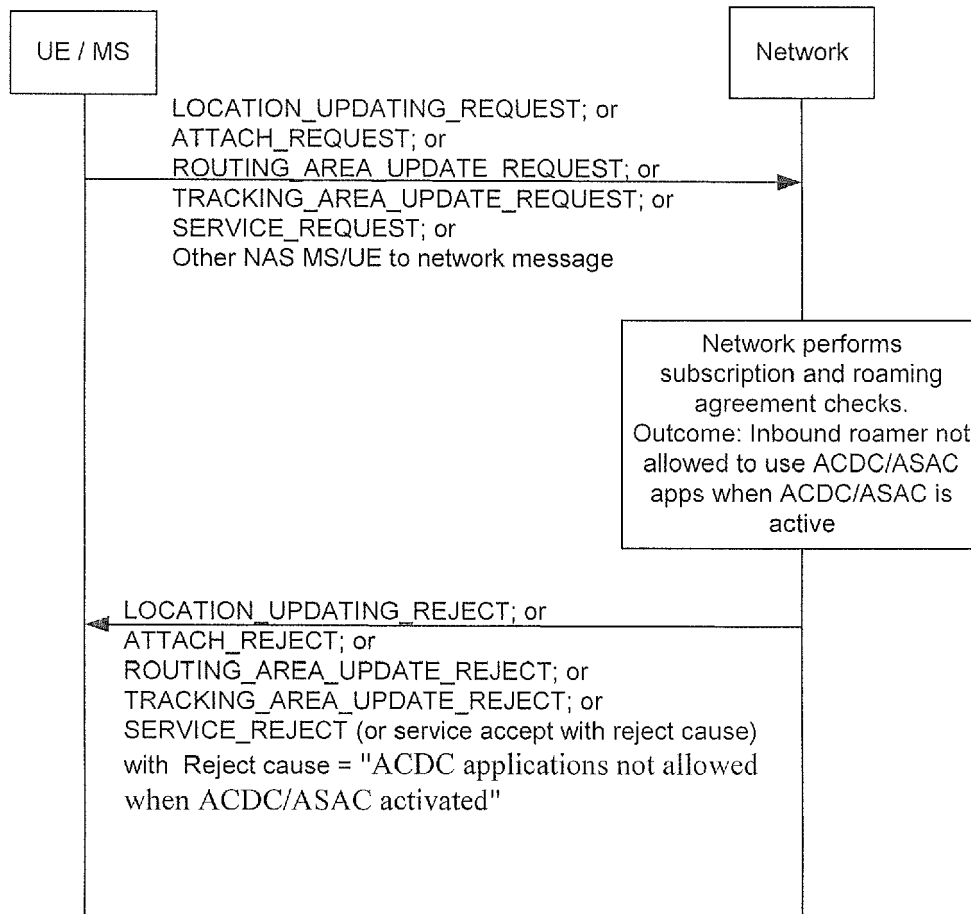


FIG. 7

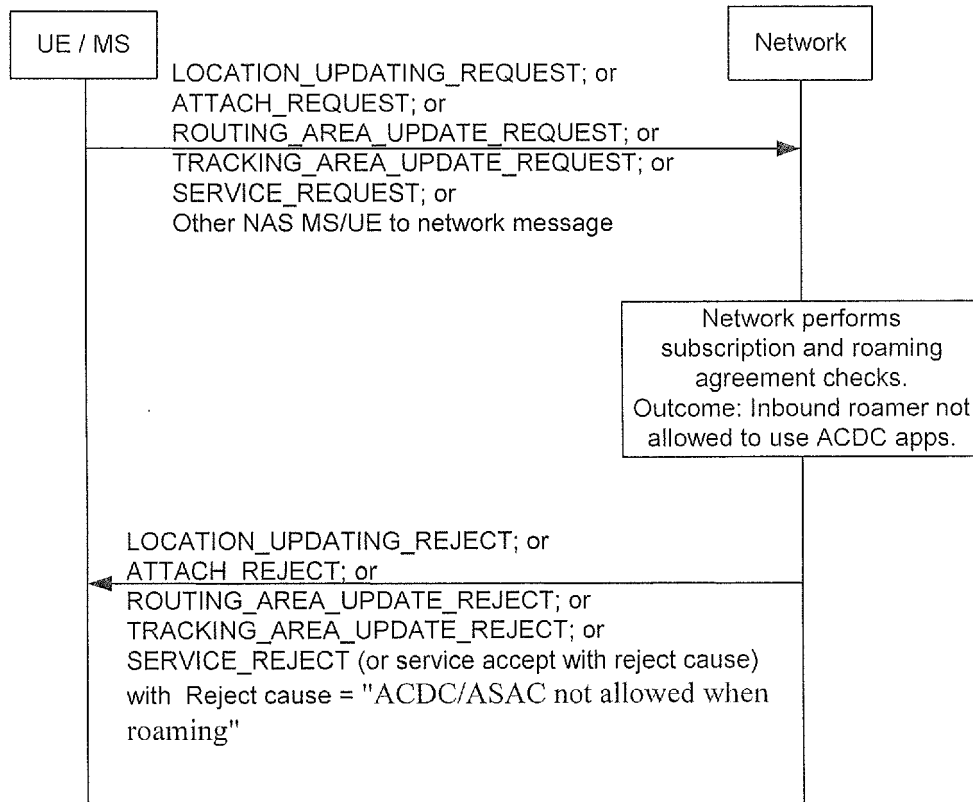


FIG. 8

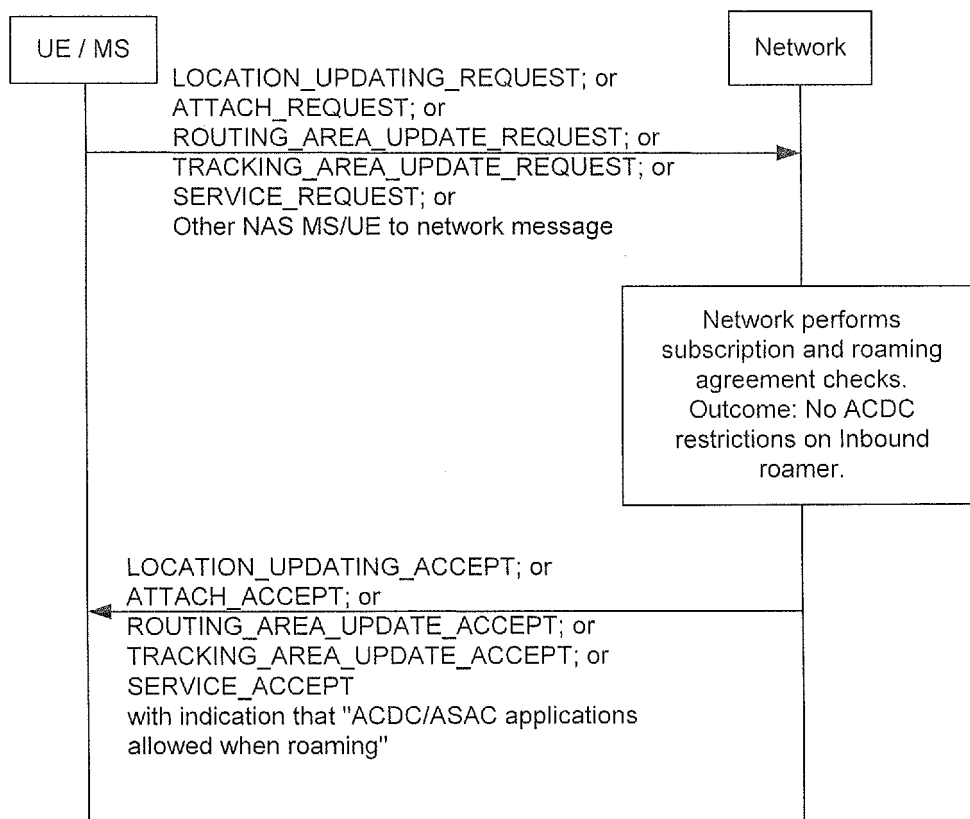


FIG. 9

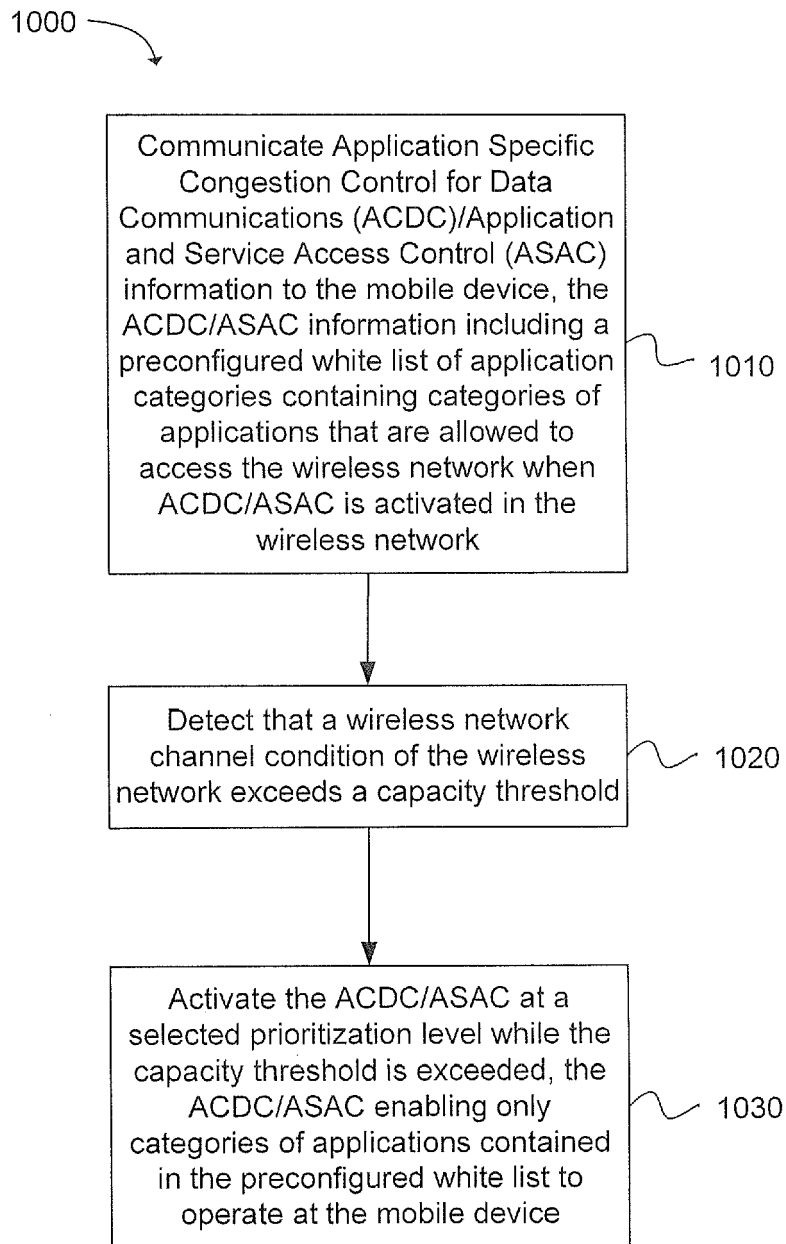


FIG. 10

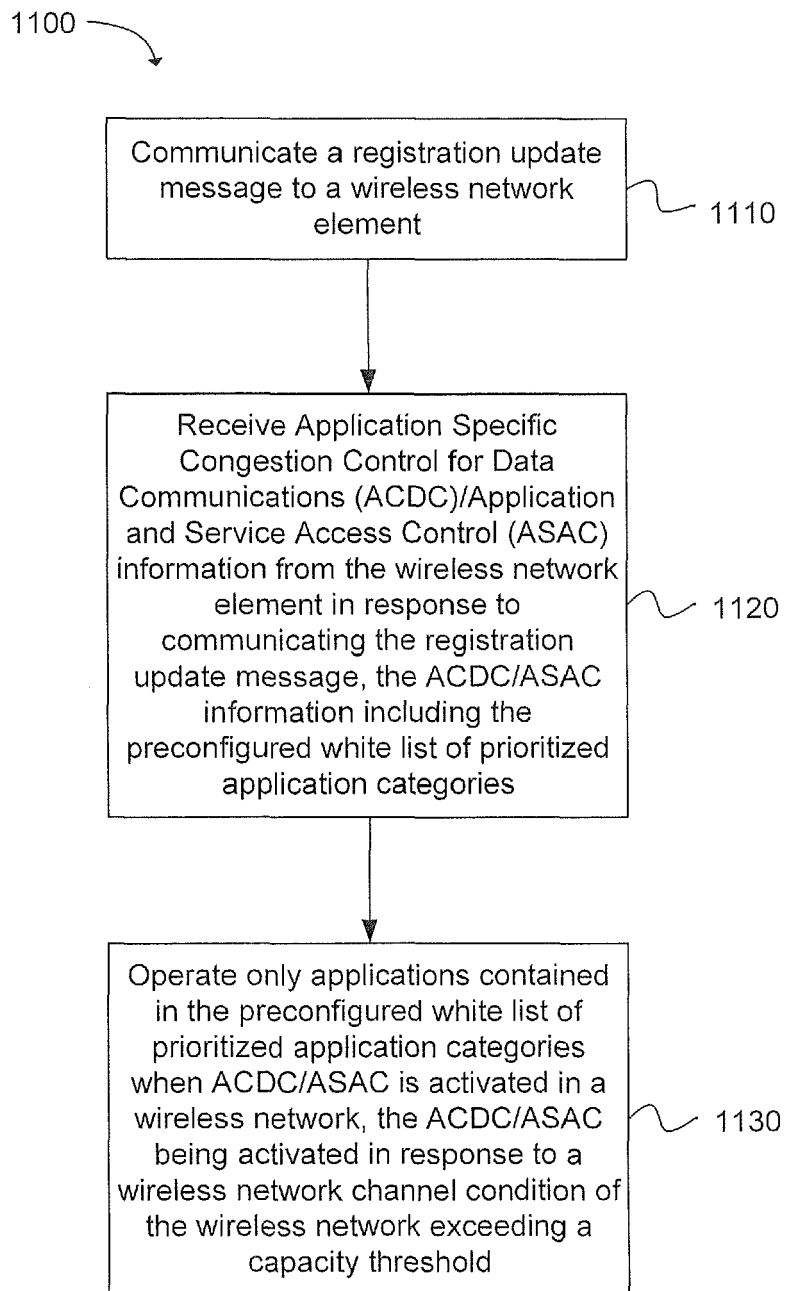


FIG. 11

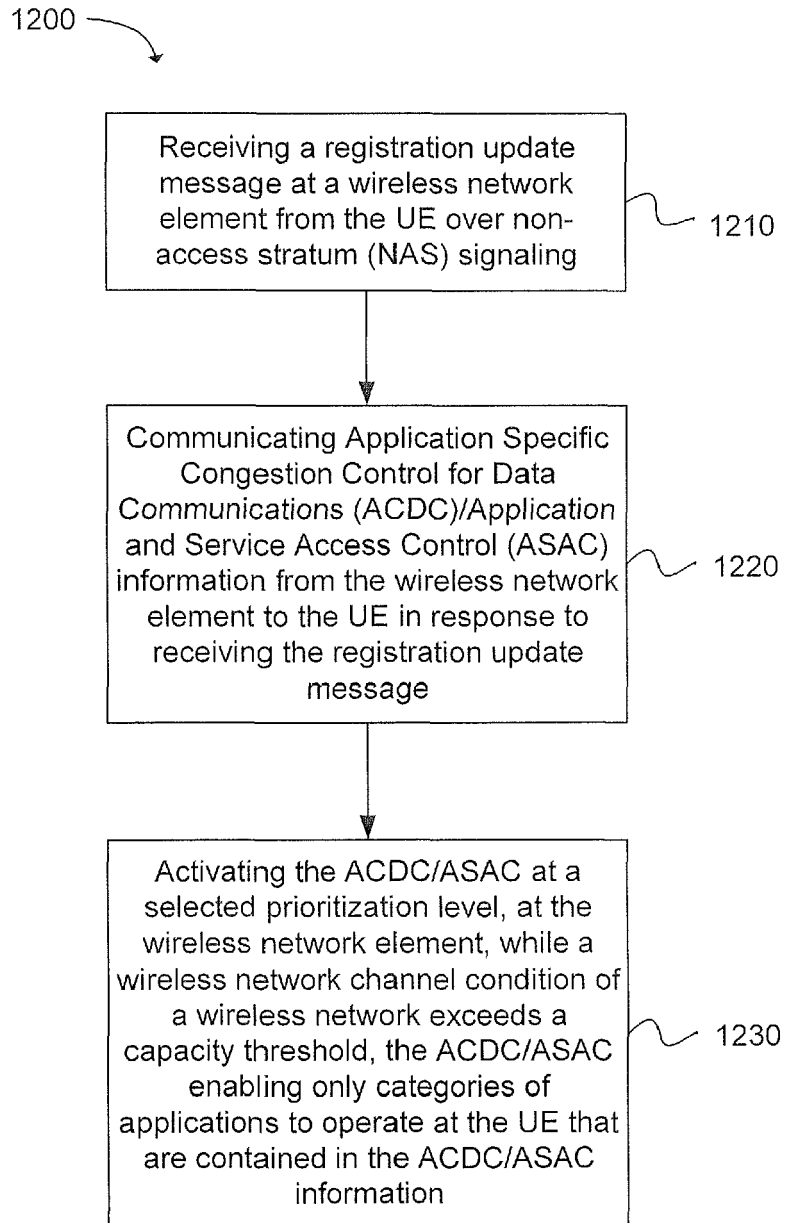


FIG. 12

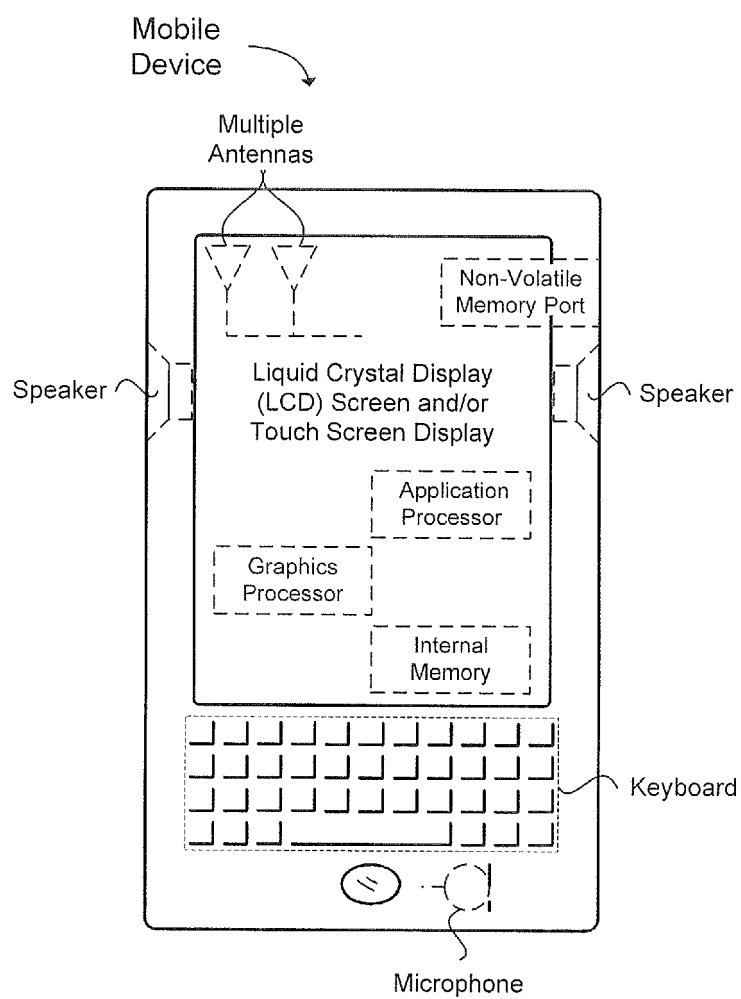


FIG. 13



EUROPEAN SEARCH REPORT

 Application Number
 EP 18 15 2277

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	NTT DOCOMO ET AL: "Requirements applied to heavy congestion scenarios of ACDC", 3GPP DRAFT; S1-131285, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. SA WG1, no. Prague, Czech Republic; 20130128 - 20130201 2 February 2013 (2013-02-02), XP050682486, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_sa/WG1_Serv/TSGS1_61_Prague/Docs/[retrieved on 2013-02-02] * paragraph [04.3] *	1-15	INV. H04B7/04 H04L1/06 H04B7/06 H04B7/08 H04L25/02 H04W72/04 H04L12/927
X	HUAWEI TECHNOLOGIES CO ET AL: "new use case on ACDC activation for UE-initiated applications", 3GPP DRAFT; S1-124281, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. SA WG1, no. Edinburgh, UK; 20121112 - 20121116 19 November 2012 (2012-11-19), XP050681717, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_sa/WG1_Serv/TSGS1_60_Edinburgh/docs/[retrieved on 2012-11-19] * paragraph [A.B.2] - paragraph [A.B.5] * ----- -/--	1-15	TECHNICAL FIELDS SEARCHED (IPC) H04B H04L H04W
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 April 2018	Examiner Gregori, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

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EUROPEAN SEARCH REPORT

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EPO FORM 1503 03.82 (P04C01)

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A	US 2013/045706 A1 (HSU CHIA-CHUN [TW]) 21 February 2013 (2013-02-21) * paragraph [0009] - paragraph [0010] * * paragraph [0023]; figure 3 * * paragraph [0025] - paragraph [0028]; claim 1 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 April 2018	Examiner Gregori, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 15 2277

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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17-04-2018

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